GROUNDWATER INFORMATION SHEET

Hexavalent Chromium

The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The information provided herein relates to groundwater sources used for public drinking water, not water served at the tap.

GENERAL INFORMATION	
Constituent of Concern	Hexavalent Chromium
Synonyms	Chromium VI, Chromium Six, Chrome 6, Cr^6
Chemical Formula	Cr^6
CAS No.	18540-29-9
Storet No.	01032
Summary	In 2014, the California State Water Resources Control Board-Division of Drinking Water (SWRCB-DDW) established the Maximum Contaminant Level (MCL) for hexavalent chromium at 10 micrograms per liter (µg/L). Based on SWRCB-DDW data from 2006 to 2016, 406 active and standby public water wells (of 12,237 wells tested) had concentrations above the MCL. Most detections of hexavalent chromium have occurred in Los Angeles (57), Riverside (47), Yolo (41), and San Bernardino (34) counties (see attached figure).

REGULATORY AND WATER QUALITY LEVELS[1] **HEXAVALENT CHROMIUM**		
Type	**Agency**	**Concentration**
Federal MCL[2]	US EPA[3]	Not established
State MCL	SWRCB-DDW[4]	10 µg/L
Detection Limit for Purposes of Reporting (DLR)	SWRCB-DDW	1 µg/L
Public Health Goal (PHG)	OEHHA[5]	0.02 µg/L
Others: IRIS[6] (non-cancer health effect) Cal/EPA Cancer Potency Factor as a drinking water level	 US EPA Cal/EPA	 21 µg/L 0.07 µg/L

[1] These levels generally relate to drinking water. Other water quality levels may exist. For further information see *A Compilation of Water Quality Goals*, 17th Edition (Marshack, 2016).
[2] MCL - Maximum Contaminant Level
[3] US EPA - United States Environmental Protection Agency
[4] SWRCB-DDW–State Water Resources Control Board-Division of Drinking Water, formerly the California Department of Public Health (transferred in 2014).
[5]OEHHA = Office of Environmental Health and Human Hazard Assessment
[6]IRIS = Integrated Risk Information System

HEXAVALENT CHROMIUM DETECTIONS IN PUBLIC WATER WELLS[7]	
Detection Type	**Number of Groundwater Sources**
Number of active and standby public wells with hexavalent chromium detections[8]	Hexavalent chromium was detected in 4,156 wells (12,237 wells tested)
Number of active and standby public water wells with Cr[6] concentrations > 10 µg/L.	406 wells
Top 4 counties having public water wells with Cr[6] concentrations > 10 µg/L.	Los Angeles (57), Riverside (47) Yolo (41) and San Bernardino (34)

[7]Based on 2006-2016 active and standby public well (groundwater sources) data collected by SWRCB-DDW.
[8]Water from active and standby public wells is typically treated to prevent exposure to chemical concentrations above the MCLs. Data from private domestic wells and wells with less than 15 service connections are not available.

ANALYTICAL INFORMATION		
Method	**Detection Limit**	**Note**
EPA 218.7	0.01 µg/L	By ion chromatography with post-column derivatization and UV-visible spectroscopic detection (SWRCB-DDW approved for drinking water)
US EPA 218.6	0.3 µg/L	By ion chromatography (SWRCB-DDW approved for drinking water)
USGS by GFAAS	0.05 µg/L	Cr^6 separation in the field, not time sensitive
Known limitations to Analytical Methods	Water sample pH must be adjusted to 9.0-9.5, stored at 4° C and analyzed within 24 hours.	
Public Drinking Water Testing Requirements	In January 2001, hexavalent chromium was identified as an unregulated chemical requiring monitoring. As a result, public water systems began to test for hexavalent chromium in their drinking water supplies to the DLR of 1 µg/L. In 2014, the MCL for hexavalent chromium was established at 10 µg/L. Results exceeding the MCL triggers quarterly monitoring.	

OCCURRENCE	
Anthropogenic Sources	Chromium is a metallic chemical that originates as a contaminant in the environment from the discharges of dye and paint pigments, wood preservatives, chrome-plating liquid wastes, and leaching from hazardous waste sites. The greatest use of chromium is in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering, etc. The two largest sources of chromium emission in the atmosphere are from the chemical manufacturing and combustion of natural gas, oil and coal.
Natural Sources	Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome-iron ore. It is also widely present in soil and plants. Under most conditions, natural chromium in the environment occurs

	as Cr^3. Under oxidizing conditions, alkaline pH range, presence of MnO_2, and minerals containing chromium, part of it may occur as hexavalent chromium dissolved in groundwater. Recent sampling of drinking water sources throughout California suggests that hexavalent chromium may occur naturally in groundwater at many locations. Naturally occurring hexavalent chromium may be associated with serpentinite-containing rock or chromium containing geologic formations.
History of Occurrence	Hexavalent chromium has been detected in groundwater at several industrial sites where wood treatment or metal plating solutions were used. Between 1952 and 1966, Pacific Gas & Electric (PG&E) used hexavalent chromium to reduce corrosion in its natural gas compressor plant in Hinkley, near Barstow. Hexavalent chromium contaminated groundwater was suspected of causing cancer and tumors in local residents beginning in the mid 1980's. Since then, elevated levels of hexavalent chromium has been detected in groundwater at several other locations including: Glendale, Topock, and Kettleman City. Hexavalent chromium also occurs naturally in groundwater at the Presidio of San Francisco and Lawrence Livermore National Laboratory.
Transport Characteristics	Hexavalent chromium is readily soluble in water. Under high Eh (oxidizing) and alkaline (pH above 7) conditions, hexavalent chromium can be predominant in groundwater. However, in the presence of organic matter, ferrous iron (Fe II) and sulfide, hexavalent chromium can be readily reduced to Cr^3 and immobilized. Adsorption of hexavalent chromium by clayey soil and natural aquifer materials is low to moderate under near-neutral pH ranges commonly encountered in groundwater.

REMEDIATION & TREATMENT TECHNOLOGIES

In-situ Treatment:
In several laboratory and field pilot tests, and full-scale remediation systems, hexavalent chromium has been removed using a permeable reactive barrier filled with zero-valent iron granules or surfactant-modified zeolite. Engineered chemical reduction technologies involve the addition or in-situ injection of an electron donor such as hydrogen sulfite, sodium dithionite, sodium metabisulfite, calcium metabisulfite calcium polysulfite or tin(II) chloride. Other methods include geochemical fixation, soil flushing and extraction, bioremediation and electrokinetics.

Above-Ground Treatment
Drinking water can be treated by different pump and treat remediation systems. Cr^3 and Cr^6 can be removed by reverse osmosis or ion exchange resin. The ion exchange method should be used with caution, as presence of other metals may interact with the process and decrease system effectiveness. Removal of Cr^6 by seaweed biosorbent and bacteria (Bacillus sp.) within packed bed reactors has also been used.

Natural Attenuation
Natural attenuation of hexavalent chromium may occur in the subsurface environment through reduction by organic matter, iron hydroxides or sulfides. Prior to selection of natural attenuation as an option for remediation, the following conditions need to be demonstrated: 1) there are natural reducers present within the aquifer, 2) the amount of hexavalent chromium and other reactive constituents do not exceed the capacity of the aquifer to reduce them, 3) the rate of hexavalent chromium reduction is greater than the rate of transport of the aqueous hexavalent chromium off the impacted site, 4) the hexavalent chromium remains immobile, and 5) there is no net oxidation of Cr^3 to Cr^6.

HEALTH EFFECT INFORMATION
Hexavalent chromium is known to cause cancer in humans when inhaled. It can also damage the lining of the nose and throat and irritate the lungs. A number of scientific studies have found elevated rates of lung cancer in workers with occupational exposure to hexavalent chromium by inhalation. A few studies of workers exposed by inhalation have shown an increase in cancers of the gastrointestinal tract. When swallowed, hexavalent chromium can upset the gastrointestinal tract and damage the liver and kidneys. In recent scientific studies of laboratory animals, hexavalent chromium has been linked to cancer when ingested, although it is rapidly converted to Cr^3 after entering the stomach and coming into contact with organic matter.

KEY REFERENCES

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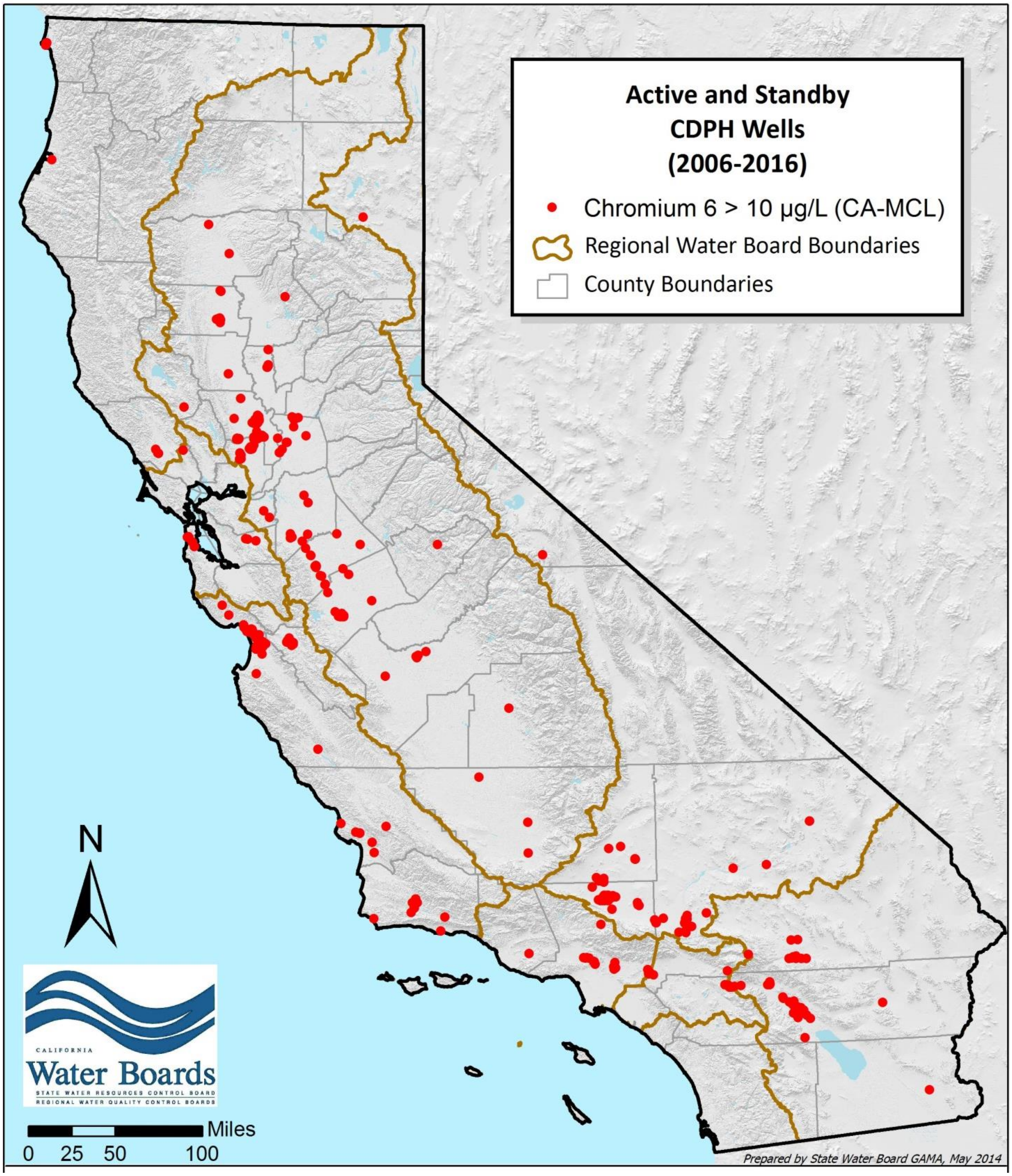

Active and Standby Public Water Wells with at least one detection of Chromium 6 above 10 µg/L (CA-MCL), 406 wells. *(Source: Public Well Data using GeoTracker GAMA).*